Journal of Physics: Conference Series **98** (2008) 072020 doi:10.1088/1742-6596/98/7/072020

The investigations of the amorphous metal properties in liquid state

V S Tsepelev[1], B A Baum[1], G V Tyagunov[1], V Y Belozerov[2], V V Vyukhin[1] and V V Konashkov[1]

[1]Institute of liquid metal physics, Urals State Technical University, 19 Mira str., Ekaterinburg, 620002, Russia

[2]GAMMAMET, Research & Production Enterprise 28, Kirova str., Ekaterinburg, 620219, Russia

E-mail: ipml@mail.ustu.ru

Abstract. A wide range of physical properties of liquid Co-based alloys has been investigated. The temperature dependencies of kinematic viscosity have shown to be non-monotonic. The correlation between the viscosity and some magnetic properties of amorphous ribbons has been established. Higher viscosity of the melt leads to better magnetic properties: higher maximum permeability, lower coercive force. The re-melting leads to increasing of the magnetic properties of produced ribbons. The optimization of temperature regime of melt preparing before amorphization has been proposed.

1. Introduction

Melts, as any other thermodynamic systems, may be divided in two groups [1-3]:
- nonequilibrium, i.e. preserving some features of structure of initial solid phase for some time;
- equilibrium, which structure and properties are determined not by pre-history but by composition and external parameters.

The interest to the systems is stimulated by following experimental facts:
- properties of molten samples of the same composition depend on pre-history (initial casting materials, heating rate and temperature);
- the melt properties are time - instable;
- the non-coincidence of properties while heating and subsequent cooling arise.

Since glass-forming alloys belong rather to the first group, in the present work we have investigated the influence of these features on the amorphous ribbons properties.

2. Results and discussion

The Co-B-Si system is a base of modern amorphous alloys with unique magnetic properties. 12 specimens with different compositions of B and Si have been studied. The Shvidkovsky method has been used for investigation of kinematic viscosity. The measurements have been made during isothermal exposures at different temperatures from 1200 up to 1700 ^{o}C in liquid state. The concentration dependences of kinematic viscosity of Co-B-Si alloy are presented in figure 1.

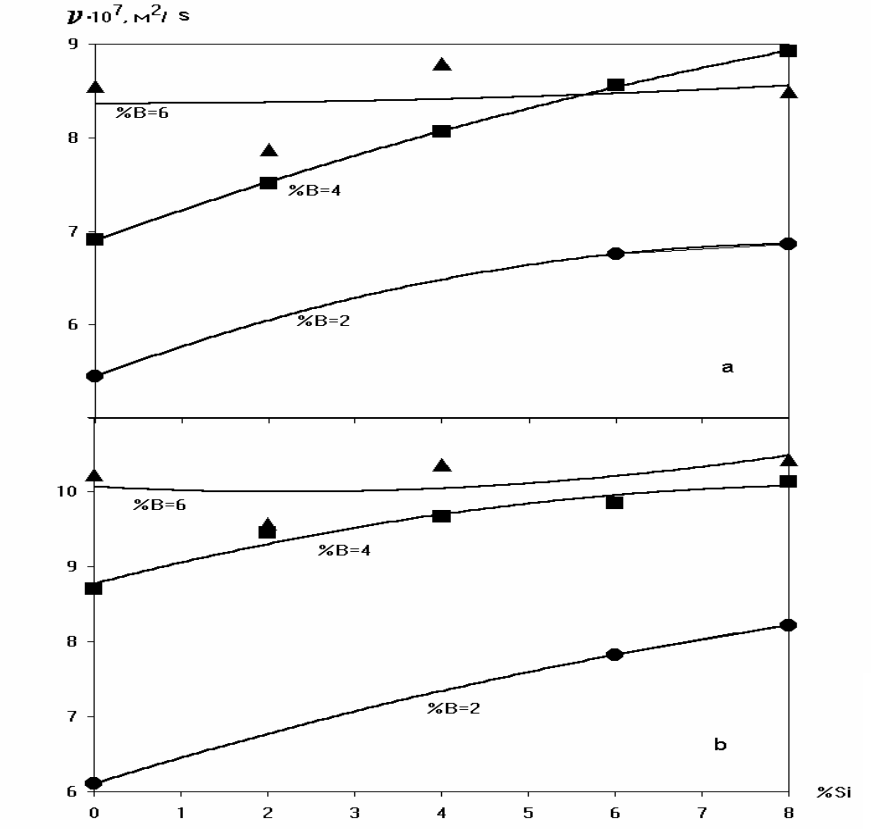

Figure 1. The kinematic viscosity of Co-B-Si alloys at a – 1500 °C, b- 1400 °C

The time instability of kinematic viscosity has been also estimated (figure 2). It has been found that heating above some stabilization temperature (critical temperature) leads to instability vanishing. The values of instability and stabilization temperature depend on the heating rate of the specimen before melting and initial charge material size. These facts justify significant change of liquid structure.

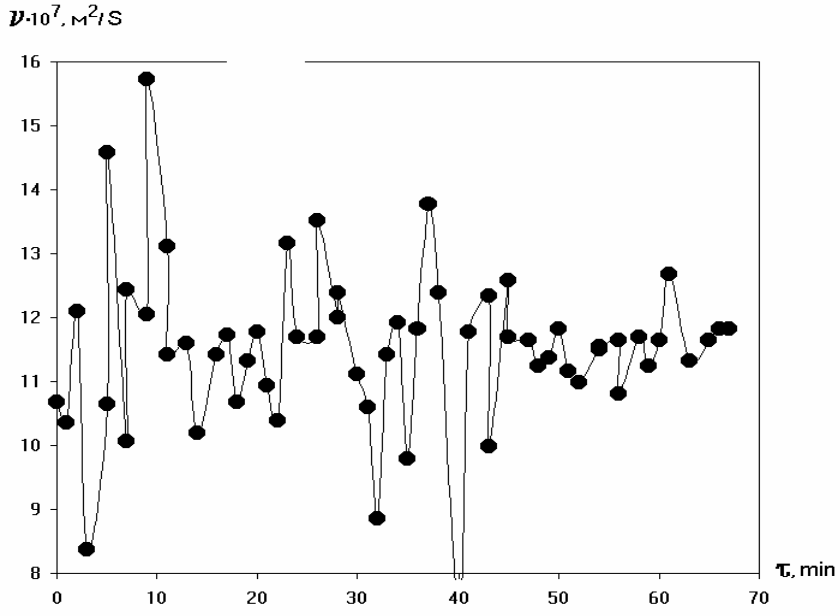

Figure 2. The typical oscillations of kinematic viscosity of Co-B-Si alloy during isothermic holding at 1300 °C

A correlation between the liquid metal viscosity at 1500°C and magnetic properties of produced ribbon has been stated out (figure 3-4). The specimens with higher viscosity have better magnetic properties: higher maximum permeability, lower coercive force.

The reason of worse magnetic properties is a high degree of non-equilibria of liquid metal before quenching. The non-equilibria of liquid metal results in inhomogeneity of short range structure and has been associated with bad quality of initial charge materials, increased amount of nonmetallic inclusions and may be reduced by appropriate temperature and time regimes of melting and casting.

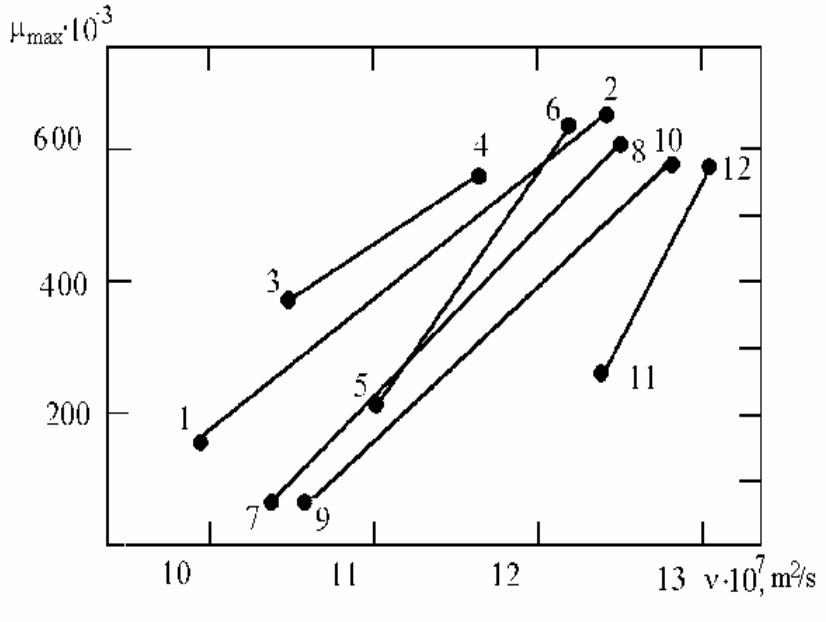

Figure 3. The dependence of maximum permeability μ_{max} from kinematic viscosity ν of melted specimens at 1500°C

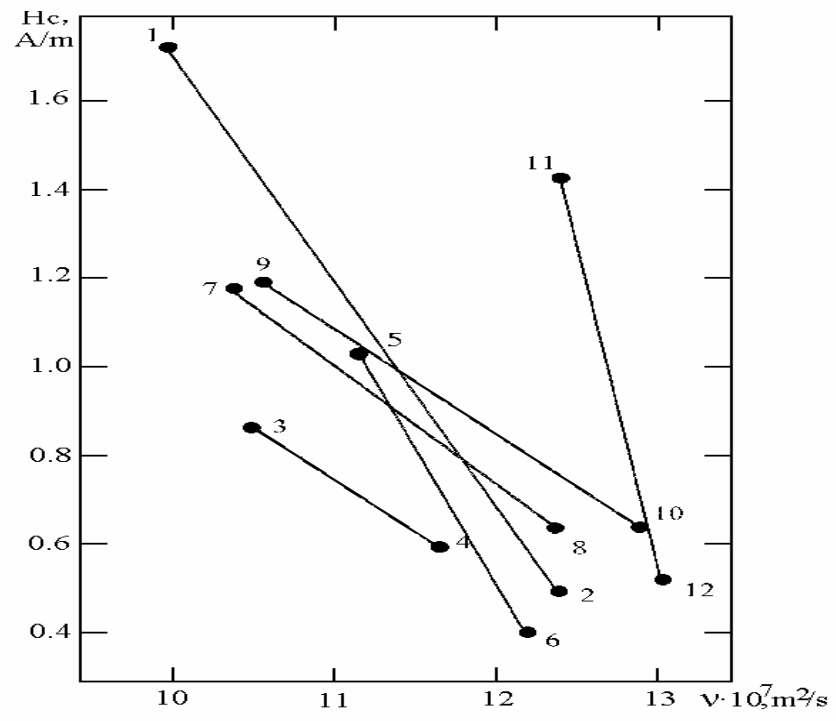

Figure 4. The dependence of coercive force H_c from kinematic viscosity ν of melted specimens at 1500°C

The results of investigation give opportunities to rise quality of amorphous and nanocrystalline ribbons. The first is to optimize the chemical composition of the alloy. The varying of temperature regime of melting and casting is the second one. In this case, the melt preparing before amorphization is needed. Maximum heating temperature must be higher then the critical one.
As it was stated, the second re-melting leads to increasing of the magnetic properties of the produced ribbons. Re-melting and heating above critical temperature lead to hereditary traits of initial charge materials disappear.

3. Summary

1. The kinematic viscosity of Co-base alloy in liquid state has been studied. It has been found that the viscosity changes from melt to melt and depend from initial charge materials and time-temperature regime of melting.
2. The quality of produced ribbons is defined by melt preparing regimes and chemical composition of the alloy. The correlation between the viscosity value and some magnetic properties of amorphous ribbons has been established. Higher viscosity of the melt leads to better magnetic properties: higher maximum permeability, lower coercive force.
3. The re-melting leads to increasing of the magnetic properties of produced ribbons.
4. The temperature regime of melt preparing before amorphization has been proposed.

4. References

[1] Baum B A 1979 *Metallic Liquids* (Moscow, Science) 120
[2] Baum B A, Khasin G A, Tyagunov G V, Klimenkov E A, Kovalenko L V, Mikhailov V M and Raspopova G A 1984 *Liquid steel* (Moskow: Metallurgy) 210
[3] Pastukhov E A, Vatolin N A and Lisin V L 2003 *Diffraction investigation of high temperature melt structure* (Ekaterinburg: Urals Brahch of RAS) 334
[4] Tsepelev V S, Baum B A, Tjagunov G V and other 2000 *Proc. Int. Conf. on Mathematical Modeling and Simulation of Metal Technologies (Ariel)* (Ariel: College of Judea and Samaria/Materials Research Center) p 646